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MARKET DISEASES OF FRUITS AND VEGETABLES:

PEACHES, PLUMS, CHERRIES AND OTHER STONE FRUITS

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MARKET DISEASES OF FRUITS AND VEGETABLES

PEACHES, PLUMS, CHERRIES, AND OTHER STONE FRUITS [1]

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HANDLING AND CARE OF STONE FRUITS ON THE MARKET

Stone fruits—peaches, plums, prunes, apricots, nectarines, and cherries—are "soft" fruits. They are all highly perishable and there-

[1] This publication is a revision of the fourth in a series designed to aid in the recognition and identification of pathological conditions of economic importance affecting fruits and vegetables in the channels of marketing, to facilitate the market inspection of these food products, and to prevent losses from such conditions. The common names of the insects mentioned are those approved for general use by the American Association of Economic Entomologists. The statements regarding fruit injuries caused by insects are made with the approval of the Bureau of Entomology and Plant Quarantine. B. A. Porter, of that Bureau, collaborated with the authors in the preparation of the entomological sections of the publication. The colored plates are reproduced from water-color paintings by staff artists of the Bureau of Plant Industry, Soils, and Agricultural Engineering, from colored photographs prepared through the collaboration of Webster Bros., Chicago, Ill., and from color photographs.

The other publications of this series are Miscellaneous Publications No. 98 (potatoes); No. 121 (tomatoes, peppers, and eggplants); No. 168 (apples, pears, and quinces); No. 292 (crucifers and cucurbits); No. 340 (grapes and other small fruits); No. 440 (asparagus, onions, beans, peas, carrots, celery, and related vegetables); No. 498 (citrus and other subtropical fruits); and No. 541 (beets, endive, escarole, globe artichokes, lettuce, rhubarb, spinach, Swiss chard, and sweetpotatoes).

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fore should be put into trade channels as soon as possible after arrival at market. Because of their perishability they should be handled carefully at all stages of the marketing process from the orchard to the consumer. In fact, there should be as little handling of any kind as possible, because every extra operation increases the danger of bruising the fruit and of spreading infection from decaying to sound fruit.

The degree of maturity, especially of peaches and apricots, always has to be considered. If the fruit is delivered ripe, the need for disposing of it promptly is much more urgent than if it is firm to firm ripe. The dealer has a little more leeway in marketing plums and prunes but not enough more so that he can be careless about how long they remain on his hands.

Rots that cause most serious damage to stone fruits on the market are brown rot (p. 6), rhizopus rot (p. 19), and blue mold rot (p. 5). They are particularly dangerous because they can develop very rapidly. Fruits that show only a few small spots of any or all of them when unloaded from a refrigerator car may become seriously damaged if held for a day or two in a dealer's wareroom at ordinary summer temperatures. The riper they are, the faster they will decay.

Plums and fresh prunes are occasionally held in storage for a while before being placed on the market. Prunes shipped immediately after harvest can ordinarily be held in cold storage for about 3 weeks after arrival at market. If they are held longer, there is danger that shriveling and internal browning, as well as abnormal flavor, will develop. Too much confidence should not be placed in the appearance and condition of the fruit while it is in storage; more deterioration—decay, shriveling, and internal browning—may take place in 3 days after removal from storage than during a 3-week storage period. Fresh prunes stored at the shipping point cannot safely be stored again after arrival on the market.

Sweating is troublesome on cherries displayed for sale soon after removal from iced cars, because of the dull appearance it gives the fruit. It is not likely to lead to decay, however, unless the fruit remains wet and warm for several hours.

ALTERNARIA ROT (GREEN MOLD ROT)

(*Alternaria* sp.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Alternaria rot is one of the common diseases of cherries on the market, although it is seldom the most destructive. It occurs on all the principal varieties of sweet cherry grown in California and the Northwest and has been found on sour cherries grown in Michigan. It has occasionally been found on the market on western plums and peaches.

The rot usually occurs as a firm, dark-brown-to-black, slightly moist spot in the shape of a cone with its apex extending toward the pit. This mass is made up of dead tissue, interpenetrated and apparently held together by the mycelium [2] of the causal fungus. It is much firmer than the surrounding healthy tissue, so that if the skin is care-

[2] Important characters common to the fungi discussed in this publication are a mycelium consisting of fine threads called hyphae and minute bodies known as

fully broken around the spot the decayed tissue can be lifted out intact. The skin on the affected area is covered with dusky olive-green sporulating hyphae, which are frequently hidden beneath a layer of white fluffy mycelium. On very small spots the aerial mycelium may be hyaline.

Typical alternaria rot is similar to cladosporium rot, or "green mold" rot (p. 11), and they often cannot be distinguished with certainty except by microscopic examination. In the case of alternaria rot, however, the surface mold is darker, the decayed tissue is moister and darker, and the enlargement of the lesions is more rapid.

Typical dark mycelium of *Alternaria* is sometimes found also in a skin-deep decay that may cover half a cherry. Apparently this type of decay follows bruising that causes some escape of juice. It is more frequently reported on sour cherries than on sweet.

CAUSAL FACTORS

The decay is induced by a fungus of the genus *Alternaria*, the species of which has not been determined. Possibly more than one species of the organism is capable of producing the characteristic symptoms. The fungus enters the cherry through breaks in the skin, either mechanical wounds received during picking and packing or cracks caused by excessive moisture just before picking. The source of inoculum is not known, but probably this fungus, like other members of its genus, lives over winter on dead material in the orchard.

CONTROL MEASURES

Since the fungus enters through wounds, care in handling will reduce the decay. After penetrating the fruit, the fungus produces decay over a wide range of temperatures, with the most rapid development at 85° F. The decayed areas continue to enlarge slowly at temperatures as low as are found in the ordinary type of refrigerator car. Rapid cooling after picking is important for control.

The development of alternaria and other rots of cherries can be greatly reduced in transit by the use of carbon dioxide gas obtained from dry ice, at the rate of about 1,000 pounds per car. Dry ice is not a substitute for the ice in the bunkers. (See *22*, *39*.)[3]

ANTHRACNOSE (BITTER ROT)

(*Glomerella* sp.[4])

Anthracnose is found occasionally on peaches grown in the South when they arrive on the market. Spots occurring on fruit in commercial shipments as a result of natural infection usually are not large (¼

spores which serve the purpose of seeds. The spores are produced on specialized branches of the mycelium or in fruiting bodies of various kinds. When carried by wind, insects, or other agencies they may lodge on fruits and other exposed plant parts throughout the orchard. With spores present on the fruit, conditions that lead to decay or other diseased conditions either in the field or in transit are as follows: Moisture on the fruit surface, skin breaks, which furnish easy entrance for the fungus, and temperatures of 50° F. or above. At temperatures below 50° infection takes place very slowly if at all. Other details concerning the effect of temperature on fungus growth are given under the various diseases. See also introduction to Miscellaneous Publication 168 (*55*).

[3] Italic numbers in parentheses refer to Literature Cited, p. 23.

[4] Probably *Glomerella cingulata* (Ston.) Spauld. and Schrenk, as indicated by inoculation tests with apples. (Personal communication from G. B. Ramsey.)

to ½ inch in diameter); often they show concentric rings of pink spore masses, as in apple bitter rot, and sometimes a slight growth of mold. Affected tissues tend to be soft and watery, but the decay does not extend deeply into the flesh.

Inoculation experiments have shown that brushed fruit may contract the disease by contact with mycelium and spores as well as through wounds. Anthracnose on a peach infected through a wound is shown in plate 1, *E*.

(See *20a*, *49a*.)

BACTERIAL SPOT

(*Xanthomonas pruni* (E. F. Sm.) Dows.[5])

OCCURRENCE, SYMPTOMS, AND EFFECTS

Bacterial spot is an orchard disease which affects fruits, twigs, and leaves of the peach, apricot, nectarine, and plum. On all of these hosts it causes the most damage by its attack on the leaves, because of excessive defoliation and consequent devitalizing of the tree. However, it often blemishes the fruit so badly that the market value of the crop is greatly reduced.

This disease has been reported from practically all peach sections of the eastern and central United States. It is usually more serious in southern fruit-growing sections, but it is sometimes seen as far north as Iowa, Michigan, and New York. All varieties of peaches are susceptible to its attack. Of the more important commercial varieties, J. H. Hale, Elberta, Carman, Sneed, and Champion generally suffer more damage than do Hiley, Belle, Early Crawford, and Salwey. The varieties of nectarines most severely affected are New White, Stanwick, and Victoria. American varieties of plums are rarely attacked, whereas the Japanese varieties, especially Abundance and Burbank, often show serious injury. Royal, one of the chief commercial varieties of apricots, is quite susceptible.

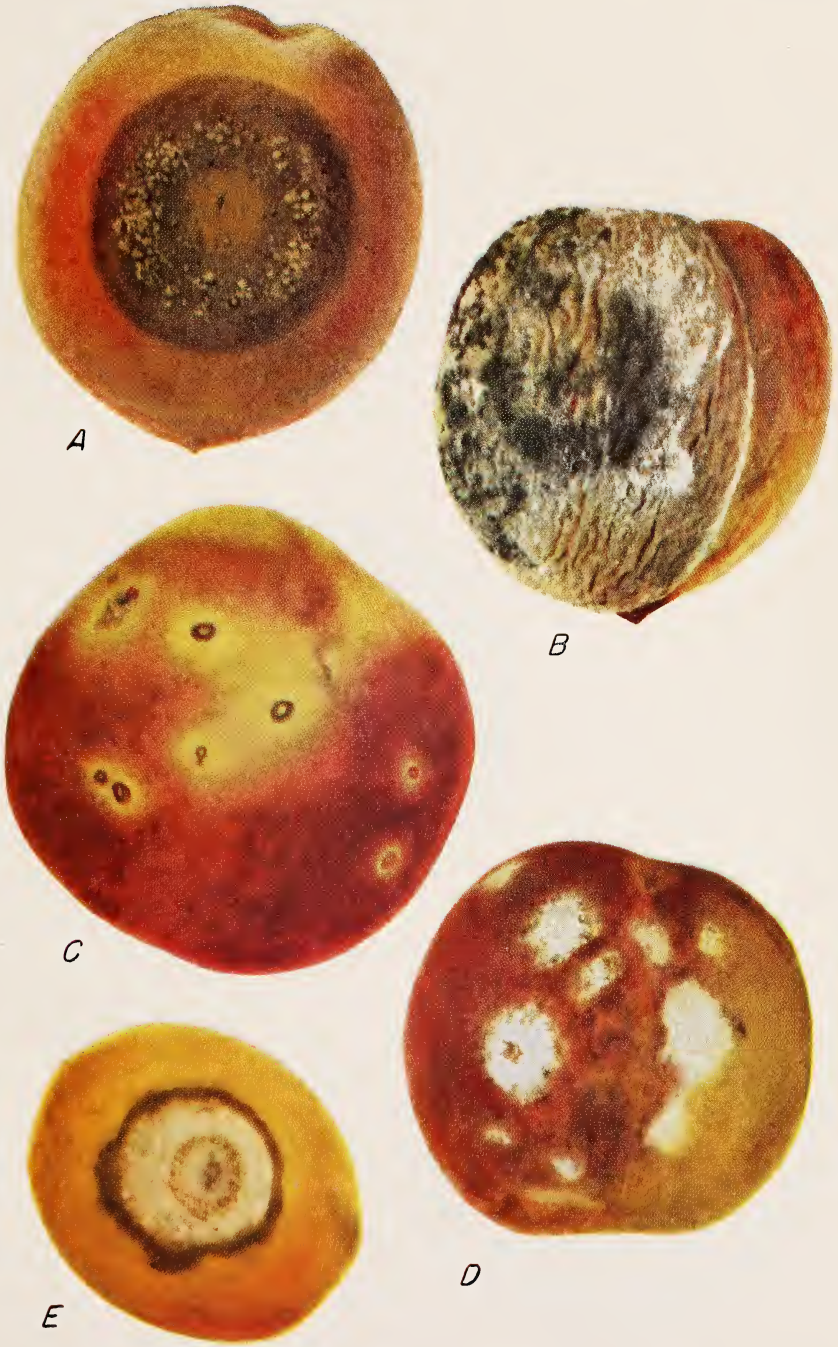
Symptoms of the disease are similar on all varieties of stone fruits, although more pronounced on some than on others. On the leaves the first symptoms are small, nearly transparent, water-soaked areas, which later turn dark, become dry and brittle, and finally fall out, producing the shot-hole appearance which has given rise to shot hole as one of the names applied to this disease. On the twigs the affected spots appear in their final stage as slightly sunken purplish-black to black areas, ½ inch to 2 inches in length and extending half to two-thirds the way around the twig.

On the fruit the disease shows first as small, circular, faint brown spots, which later enlarge and grow darker. As the disease progresses, affected tissues dry out and crack, the cracks becoming so marked in later stages, when they deepen and run together, that they constitute a serious blemish and sometimes render the fruit unmarketable (pl. 2, *A*). On peaches and nectarines, on which the cracking is most severe, bacterial spot is occasionally followed by infection with blue mold and other decay fungi.

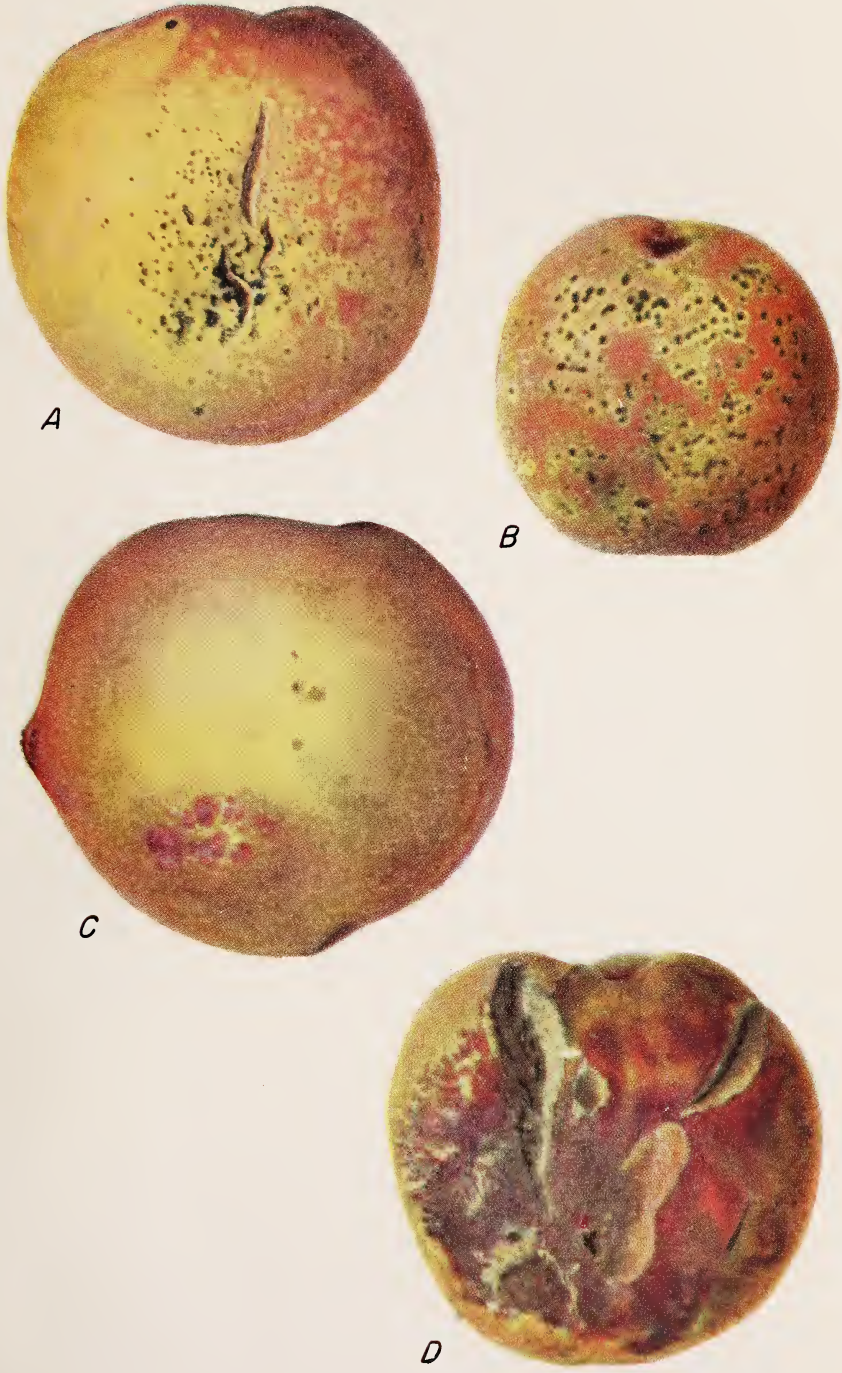
CAUSAL FACTORS

Bacterial spot, caused by *Xanthomonas pruni*, was first described in 1902 on Japanese plums but has since been found on all stone fruits.

[5] Syn., *Bacterium pruni* E. F. Sm.; *Phytomonas pruni* (E. F. Sm.) Bergey et al.



A, Brown rot of peach; *B*, rhizopus rot of peach; *C*, *D*, powdery mildew of peach; *E*, anthracnose (bitter rot) of peach.



A, Bacterial spot of peach; *B*, scab of peach; *C*, *D*, leaf curl on peach.

It is rare on cherries. The bacteria overwinter on the twigs and are spread from these in the spring and early summer when the bacterial ooze drips or is splashed onto leaves and fruit below by drops of rain or dew. Bacteria exuding from leaf and fruit spots constitute a secondary source of infective material, which is believed to be distributed in the same way. Wind is also thought to be a factor in the distribution of the pathogen, since it causes a wider scattering of raindrops or dewdrops than would occur in still air.

CONTROL MEASURES

Proper pruning, cultivation, and fertilization, especially with nitrate of soda, tend to mitigate the effects of bacterial spot by keeping the trees growing vigorously. A spray composed of zinc sulfate and hydrated lime has been shown to decrease defoliation and to increase the percentage of marketable fruits when the spray is used at 2-week intervals throughout the growing season, starting with petal fall.

(See *3*, *4*, *20*, *32*, *53*, *54*.)

BLACK MOLD ROT

(*Aspergillus niger* v. Tiegh.)

Black mold rot of peaches and cherries has been reported only from the West, chiefly from California. So far as known the causal fungus may attack any variety, but there is no record of its having caused serious loss at any time.

The lesions produced on peaches are small and shallow. There is slight browning of the affected flesh and practically always a scanty growth of the fungus on the surface. Before spore production begins this is merely a white mycelium not readily distinguishable from that of gray mold (p. 14). After spores are produced, in characteristic black or purplish-black clumps, the white is masked and the growth has a sooty appearance. On sweet cherries the rotted tissue is watery and mushy and can be scooped out, leaving a clean hollow in the surrounding flesh. The epidermis covering the spot usually shows several cracks through which the fungus appears in small, white tufts that later turn jet black with the production of sooty spore masses.

This decay is important only on fruit held at high temperatures. Nothing is known of when or how infection takes place or of how it can be prevented.

BLUE MOLD ROT

(*Penicillium* sp.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Blue mold rot occurs on all kinds of stone fruits but is more common on cherries and plums than on peaches and apricots. On the first two kinds it is often more destructive during the marketing process than any other rot except possibly rhizopus rot (p. 19). It rarely affects any of the stone fruits on the tree.

In early stages on cherries the rot is characterized by a circular flat area covering a cone of very soft and watery light-brown tissue. The decayed mass can be scooped out cleanly from the surrounding healthy tissue. The skin covering it cracks readily, and through the cracks small, white, tufted cushions of the fungus grow (pl. 3, *B*).

Under humid conditions the spot may be entirely covered with a scanty growth of mold, white at first but soon turning bluish green with the production of powdery spore masses. Cherries severely affected with the decay become crushed in the package during handling on the market and the decayed tissues smear the surrounding fruit. On peaches and plums blue mold produces soft watery spots of decay that are light brown in color (pl. 4, *A*).

CAUSAL FACTORS

The causal fungus, an unidentified species of *Penicillium*, is common in nature on dead or decaying material of various kinds. It produces immense numbers of spores, which are the chief means by which it spreads. In the orchard during the growing season, although temperatures are rarely unfavorable for the rot, the fruit is not susceptible to attack by blue mold rot until it becomes mature.

Conditions in transit often are distinctly favorable to the spread of the disease. Excessively tight packing, careless handling prior to loading, or rough handling of the car in transit may cause skin breaks; rain or heavy dews at picking time may cause the fruit surface to be moist at loading time or a very humid atmosphere in the car may cause it to become so soon afterward; the temperature may be favorable for the fungus, above 50° F., especially at first, if the fruit is loaded warm and icing is delayed or inadequate. As a result, any decay spots already present will develop further and new ones will start where injuries occur.

CONTROL MEASURES

Since the blue mold fungus seldom if ever enters the fruit through the unbroken skin, it is important to prevent punctures during all the handling operations. Special care should be exercised to prevent crushing of the fruit in the picking and packing operations.

Cherries should be placed in a cold place as soon after picking as possible. Throughout the transit period temperatures considerably below 50° F. (between 40° and 45°) are necessary if losses are to be prevented, but the fungus can make some growth even at 32°. The temperatures recommended are best obtained by careful attention to icing and by precooling the fruit either in the warehouse before loading or in the car immediately after loading is completed. Salting the ice will hasten cooling. During precooling in the car, or in shipment of warm fruit, salt to the extent of 5 percent of the weight of the ice may be used. With precooled fruit not more than 3 percent of salt should be added, because of danger of freezing. Delay in transit may increase the damage from rot, because it gives the fungus a longer time in which to work.

(See *9*, *69*.)

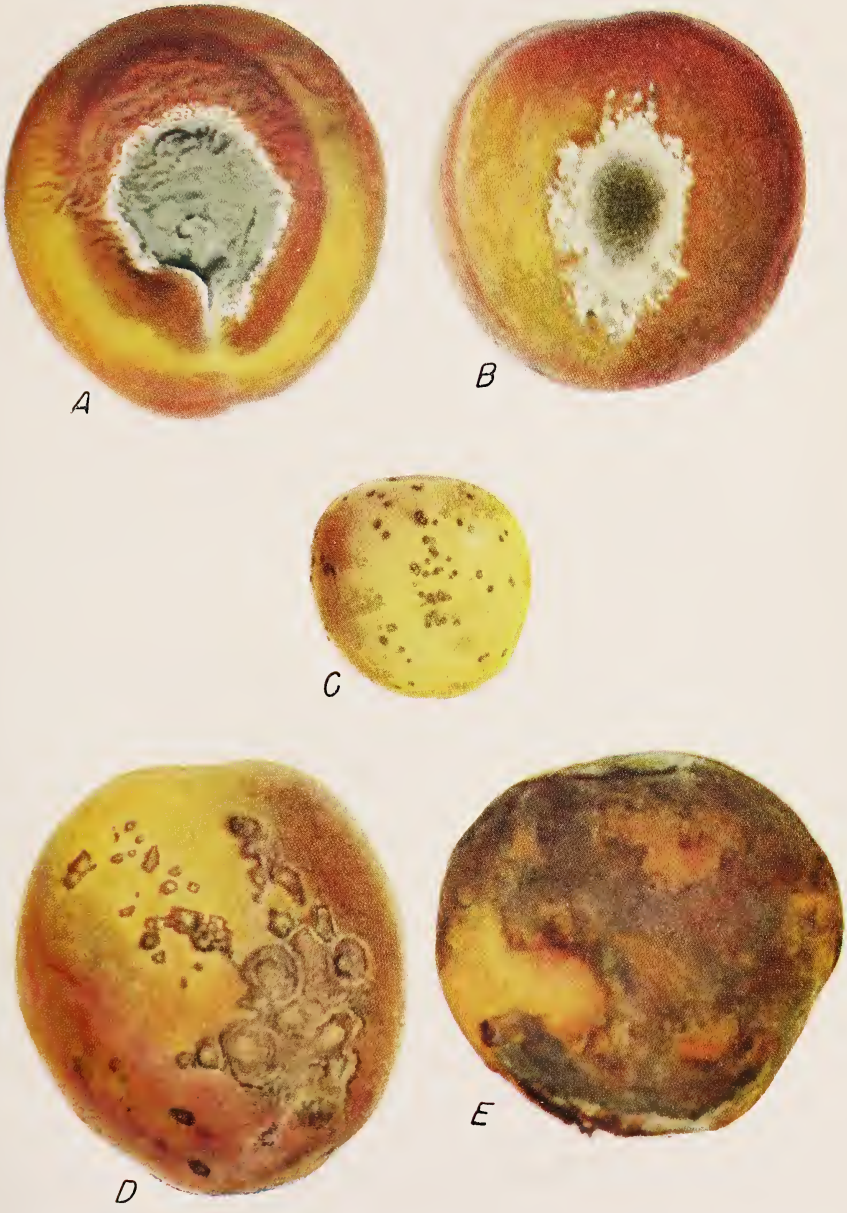
BROWN ROT

(*Monilinia fructicola* (Wint.) Honey)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Brown rot is a disease primarily of the stone fruits, although it sometimes occurs on pome fruits as well. It will be considered here only in reference to stone fruits.

A, Cladosporium rot of cherry; *B*, blue mold rot of cherry; *C*, *D*, brown rot of cherry.



A, Blue mold rot of peach; *B*, gray mold rot of peach; *C*, scab, or physiological spot, of apricot; *D* California blight, or pustular spot, of peach; *E*, sulfur dioxide injury of peach.

Brown rot originates in the orchard but may cause damage at any stage of the marketing process or even after the fruit reaches the consumer. In the orchard it occurs on leaves, blossoms, fruits, twigs, and limbs, the completeness of the attack depending to a considerable degree on which of the stone fruits is affected and on temperature and moisture conditions.

The disease on the fruit appears at first as small, circular, light-brown spots, which under conditions favorable to infection (at temperatures of 60° to 80° F.) may enlarge so rapidly as to bring about complete decay in 24 hours. The spots at no stage are sunken, and the flesh remains firm. In late stages the skin turns dark brown or even black. The easily observed yellowish-gray masses on the surface of rotted spots are composed of millions of spores, which can start the disease on other fruits (pl. 1, *A*). In early stages the rot on cherries is brown of a considerably lighter color than that of the normal fruit; later this brown gradually darkens and the margin of the lesion fades into the normal flesh color, leaving no distinct line separating decayed from healthy tissue. The skin covering the lesion remains firmly attached to the tissue beneath (pl. 3, *C*, *D*; pl. 5, *B*). The characteristics of the rot on plums (pl. 6, *D*) are similar to those on peaches.

In the eastern United States and in the humid sections of Washington and Oregon, brown rot occurs on all stone fruits; in California it is found chiefly on apricots and cherries. It sometimes occurs in California peach orchards and is sometimes severe on the market on peaches grown in that State.

CAUSAL FACTORS

The fungus that causes brown rot, *Monilinia fructicola*, winters over chiefly on mummies adhering to the branches and on rotted fruit that falls to the ground; it also winters over to a slight extent on twig and limb cankers. During wet weather in the growing season it produces immense numbers of spores on mummies, on infected blossoms, and on twig and limb cankers. The spores find lodgment everywhere but are of greatest importance on the blossoms and fruits, which are very susceptible to attack. Diseased blossoms and twig cankers are important sources of infection in prune and cherry orchards.

Development and spread of the disease in the orchard, particularly on the fruit, are closely associated with warm, wet weather. A prolonged drizzly spell or a series of cloudy days with frequent showers is more dangerous than a heavy rain followed by clearing. Since summer temperatures in any stone-fruit section are usually well above the minimum required for the development of brown rot, the chief determining factor in all sections is moisture.

Immature fruit is less susceptible than fully ripened fruit. Breaks in the skin due to careless handling, to wind whipping or hail, to insect injury, or to the cracking that often accompanies scab tend greatly to increase infection. In fact, without skin breaks there seems to be little danger of infection, except under conditions of moisture and temperature particularly favorable to the causal fungus, as, for example, in the upper layers of a carload, where the fruit may be too warm for 12 hours or more. Under such conditions the fungus is apparently able to penetrate the uninjured skin of the fruit and may spread from one fruit to another by contact.

Growers and shippers find that different shipments of their fruit often arrive in different condition at the market even though the fruit is of the same variety, the same methods of picking and packing have been used, and the shipments have had what seemed to be the same conditions in transit. If the identity in treatment really exists, the difference in final condition is usually a matter of weather at the shipping point. It may occasionally be due to difference in maturity.

In sections where brown rot occurs, if wet weather prevails when the crop is being harvested, the disease and the spores of the fungus will be abundant in the orchard. Some fruits with small rotten spots are likely to be overlooked by the packers; infected fruit may be packed at a stage when infection is not visible as discolored spots; or fruit may be packed on which spores have lodged but have not yet caused infection. If conditions in transit are favorable to the causal fungus, the rotten spots already present (whether visible or not) will enlarge and new ones will be formed as a result of the germination of spores lodged on the fruit.

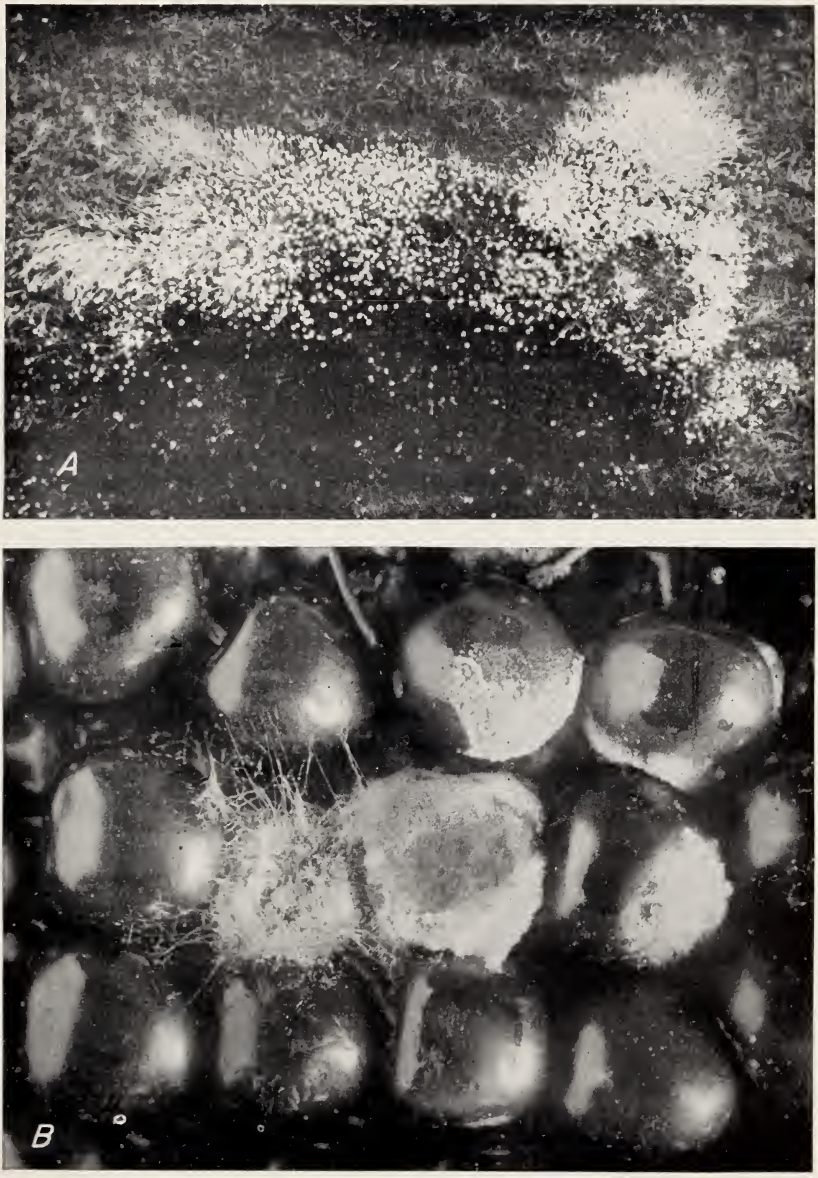
If the weather is dry at picking time, brown rot spores will be scarce on the fruit and there will be little or no infection, either visible or invisible; consequently the chances will be good that very little decay will develop in transit, even under conditions that might have allowed much of it if the fruit had been picked during wet weather.

Peaches harvested in brown rot territory in wet weather are not necessarily sure to rot in transit under good conditions. However, it is true that too often the conditions under which the crop is handled and moved to market are not such as to hold brown rot in check. Frequently there are not sufficient care and expedition in picking and packing. In transit there is usually moisture enough present for spore germination, so that development and spread of the rot depend mainly on temperature. New infection is almost entirely prevented by temperatures below 50° F., and the development of rot already present is checked somewhat at 50° and to a still greater extent the lower the temperature goes; but the fungus when already established is able to make some progress even at 32°. The upper limit of safety, that is, the temperature that will prevent serious loss during the ordinary transit time, is about 45°.

Chief among insects associated with brown rot or concerned in the distribution of brown rot spores is the plum curculio (p. 17). When the curculio and the rot occur in the same fruit, infection probably took place at the egg-laying puncture through spores carried by the insect or lodged there by the wind. When the rot occurs alone, infection may have taken place at a curculio feeding puncture or some other skin break or directly through the otherwise sound, undamaged skin. Injuries caused by the oriental fruit moth (p. 16) frequently become infected with the rot. In the Northwest, stone fruits grown west of the Cascade Range sometimes become infected with brown rot at injuries made by the syneta leaf beetle (*Syneta albida* Lec.).

CONTROL MEASURES

Brown rot can usually be controlled in the orchard by some form of sulfur combined with a suitable insecticide (for the control of curculio (p. 17)). For details, the United States Department of Agriculture or the State agricultural colleges should be consulted. Dusting



A, Rhizopus rot on surface of rotting peach, showing sporangia of causal fungus, × about 10; *B*, brown and rhizopus rots of cherry, slightly enlarged.

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A–C, Cracking of cherry; *D*, brown rot of plum.

stone fruits with sulfur shortly before harvest is decidedly effective in improving their carrying quality.

If fruit is loaded hot, say with a temperature of 80° to 90° F. (or even higher, as sometimes happens), it may take 48 hours to cool below 50°, even though it is moving in a car with bunkers iced to capacity at all icing stations en route to market. Such a delay in cooling and similar delays due to belated or otherwise faulty icing of the car give time for old infections to enlarge or new ones to start and are responsible for much of the loss that this disease causes on fruit in transit. Delays in movement of the car may also increase the loss, by giving the brown rot fungus a longer time in which to work.

In end-bunker refrigerator cars not equipped with fans, brown rot is usually worse at the top of the load than at the bottom. This is because of higher temperatures at the top in such cars. In cars equipped with fans under the floor racks temperatures are more nearly uniform throughout the load and generally lower than in cars without fans, so that the rot is likely to be controlled better and to about the same extent in all parts of the load. (For fuller discussion, see Rhizopus Rot, p. 19.)

Precooling either before loading or by means of an apparatus that reverses the air circulation in the car is usually very beneficial. Precooling in the car reduces the difference in temperature between top and bottom of the load, and it hastens cooling in all parts of the load, especially in the upper layers. For best results, 2 to 6 hours' precooling in the car, depending on the type of blower used, and the addition of 3 to 4 percent salt to the bunker ice during the precooling should be the practice with moderately warm fruit. If the fruit is hot (90° F. or higher), 3 to 8 hours' precooling, again depending on the type of blower used, and 5 percent salt are needed to bring it to a temperature that will prevent the development of rot. Under either of these conditions there is very little danger of freezing, because practically all the salt will be used up before precooling is finished.

(See *1*, *4*, *6*, *7*, *9*, *12*, *13*, *14*, *15*, *16*, *18*, *22*, *23*, *24*, *27*, *30*, *31*, *33*, *36*, *39*, *41*, *44*, *46*, *50*, *51*, *52*, *56*, *58*, *59*, *60*, *64*, *69*.)

BRUISING

Bruising may occur on all stone fruits, but is most common on plums and peaches. It may be caused by careless handling in picking or packing, by packing too tightly, to high, or too loosely in the package, or by rough handling in transit (pl. 7, *A–C*). If bruising is only moderate it blemishes the fruit; if severe it causes skin breaks that let in various decay organisms. The riper the fruit the greater the damage.

Bruises on peaches are sometimes mistaken for rot. To distinguish the two it is only necessary to remember that bruised peach flesh has a mottled brown and white appearance and the skin is not browned, whereas in rotten spots both skin and flesh are brown. The shade of brown varies somewhat with the kind of rot.

In packed boxes of sweet cherries, bruises in the form of translucent, brownish discolorations midway between the pit and the skin are frequently found in fruits on the faces of packs that bulge too much and in fruits that have been pressed together in packing. The skin of the cherry above the discoloration appears normal except when the injury has been severe. In loosely packed lugs cherries of the Na-

poleon (Royal Ann) variety next to the lid sometimes exhibit a scalded appearance of the skin. This results from the excessive chafing the fruit receives in transit. Bruising and discoloration are not restricted to any one variety of sweet cherries but are most noticeable on the Napoleon because of its light-colored skin and flesh (*10*).

CALIFORNIA BLIGHT

(*Coryneum beijerinckii* Oud.[6])

California blight, known also as peach blight, shot hole, brown spot, pustular spot, and winter blight, is a fungus disease which originates in the orchard, where it causes leaf spots and shot holing, twig and limb cankers, and spotting or rotting of fruit. It occurs rather commonly on peaches in California, Colorado, and Utah, and is sometimes seen on this fruit in Indiana, Michigan, New York, Ohio, and Oregon. The disease occurs also on plums, cherries, and apricots (*5*).

Infected spots on peaches are at first purplish red, small, and distinct from one another. Later, as they enlarge, they have white centers surrounded by brown areas ⅛ to ¼ inch in diameter (pl. 4, *D*) and become slightly sunken. There is evidently some development in transit, because peaches found affected with the disease on the market frequently show lesions much larger than those common in the orchard: that is, ½ inch or more in diameter, and depressed ⅛ to ¼ inch below the surrounding healthy skin. In some instances the spots on fruit arriving at market are found to have coalesced and formed diseased patches covering a fourth or more of the fruit. Cracks may develop in the diseased areas, and the cracking is sometimes followed by a flow of gum. Infection with brown rot or rhizopus rot fungi sometimes occurs at the spots, but usually the affected tissues have such a dry, corky texture that decay fungi do not readily attack them.

On cherries affected with California blight there are usually only one or two spots: in these the fungus causes a drying of the flesh to the stone, or a spreading infection that may involve the whole fruit.

A spotting of apricots known as scab or shot hole (pl. 4, *C*) occurs in California and the Pacific Northwest. It resembles the early stages of California blight on peaches and is sometimes considered to be a form of that disease, but it is not positively known to be caused by the blight fungus. Failure to control it by repeated spraying with bordeaux mixture causes some investigators to believe that this disease is physiological or nonparasitic.

Under ordinary conditions California blight can be controlled in the orchard by spraying with 10–10–100 bordeaux mixture as soon as the leaves are off in the fall or even before all of them are gone. When infection is common and severe because of warm, rainy weather, it may be necessary to spray again in the spring about a month ahead of blossoming time. Although nothing specific is known concerning the effect of temperature on the disease, it is probable that very little enlargement of the spots will occur in transit if the fruit temperature is kept at 45° F. or slightly lower.

(See *17*, *21*, *30*, *31*, *47*, *61*.)

[6] Probably synonymous with *Clasterosporium carpophilum* (Lév.) Aderh., according to a personal communication from A. A. Nightingale.

Bruising of peaches: *A*, *B*, Individual fruits; *C*, fruits at top of a tightly packed basket.

CLADOSPORIUM ROT (GREEN MOLD ROT)

(*Cladosporium* sp.[7])

In some seasons cladosporium rot is found very frequently on eastern markets on sweet cherries from California, Oregon, Washington, and Idaho. It is found occasionally on peaches and plums from California. The decayed spot is usually small, often merely lining the wound around which it centers with a thin layer of decayed tissue. Spots larger than 1 inch in diameter have not been found on peaches. A thin fluffy growth of white mycelium covers the spot and often extends somewhat beyond the decayed area. Later the aerial mycelium turns yellowish olive, with abundant spore production (pl. 3, *A*). The most striking feature of the decay is a hard cone-shaped core with its apex extending deep into the fruit. This gray to black core is dry and can easily be removed from the surrounding healthy tissue. Usually a thin layer of moist brown tissue lines the cavity in which it developed. Cladosporium rot very commonly follows cracking in cherries, and during seasons when cracking is severe on fruit grown in the West cladosporium rot follows in most of it.

Cladosporium sp., the fungus associated with the decay, belongs to a widespread group of organisms that live and sporulate abundantly on dead plant materials. Nothing is known of the orchard history of the specific organism causing the decay, but since the fungus is common on cherries from so many sections it is reasonable to suppose that it is common in orchards and packing houses. The spots of decay enlarge most rapidly at about 72° F. but develop slowly at temperatures as low as 34°. Frequently other organisms such as *Penicillium* gain entrance and quickly destroy all primary symptoms.

Since *Cladosporium* sp. enters the fruit only through breaks in the skin, it is apparent that a very important control measure is the prevention of wounds. All cracked cherries should be discarded before the packing is done. Rapid cooling after picking will retard the development of decay, but cannot be relied on to prevent it (*9*).

COLD-STORAGE INJURY

In order to prolong the marketing season and avoid gluts, peaches are sometimes held in cold storage for periods ranging from a few days to 3 weeks or even longer. The shorter storage seems to have little or no bad effect on the appearance, texture, or flavor of the fruit. Prolonged storage, on the other hand, is usually harmful to all of these. The peaches lose their natural bright color, become dry and mealy, and eventually have an acid, astringent flavor. In addition they may develop break-down, the first indication of which is either mealiness or a water-soaked appearance around the stone (pl. 8, *B*). In later stages the water-soaked regions become larger and turn brown. Brown spots may also develop on the skin (pl. 8, *A*).

Differences in the behavior of various lots of peaches in storage may be caused by differences in maturity. There are also varietal differences. It has been found, for example, that under comparable conditions Carman and Belle peaches develop storage break-down sooner

[7] Not the species that causes scab of stone fruits.

than Elberta and that none of these remain free of it as long as J. H. Hale and Late Crawford. The best storage temperature is from 31° to 32° F., and the maximum storage period without deterioration is not longer than 3 weeks, even for the best keepers (*27*).

When sweet cherries are held in cold storage for 2 or 3 weeks they sometimes become pitted. The pits are usually elongated in shape, of irregular outline, and brownish in color, especially on light-colored cherries. The larger spots are frequently underlain by a brownish discoloration of the flesh, in which small hollow spots may develop as desiccation proceeds.

This trouble may be followed by infection with decay organisms.

CRACKING

In an occasional season much cracking is found in cherries on the market. All varieties are susceptible, but some are more apt to crack than others. The Bing variety cracks more readily than the Lambert or the Napoleon, and the Montmorency less than any of the sweet varieties.

Cracking of cherries is usually caused by wetting of the fruit with rain while still on the tree, although it may occur in transit if the fruit is covered with free moisture for long periods.

The extent of cracking induced by free moisture on the cherry depends on the concentration of the fruit juice, the turgor of the fruit, the temperature of the water, and the permeability of the skin. The fruit is most susceptible when fully mature, because at that time it has filled out and contains more sugar, so that the concentration of the juice is high. Under such conditions the underlying tissues swell rapidly, stretch the skin, and finally split it.

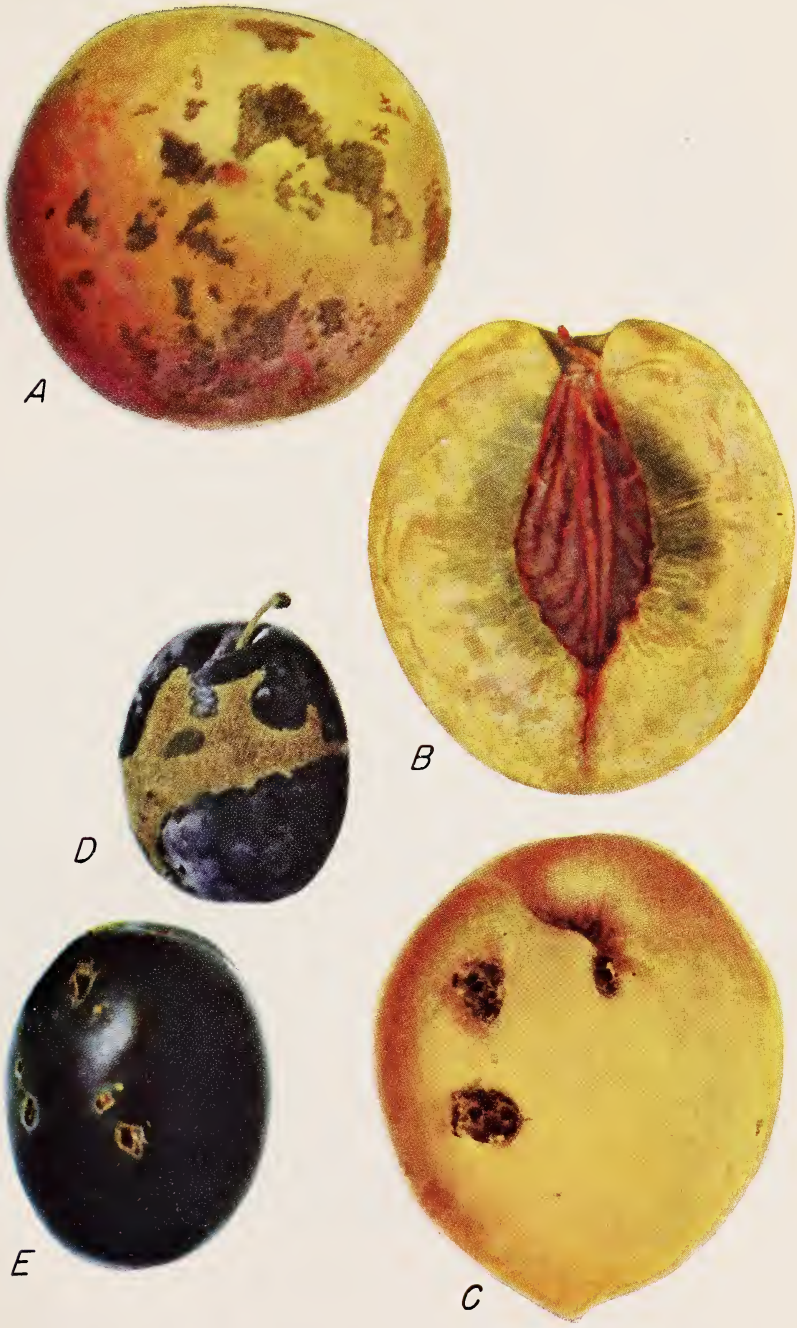
The location of the cracks on the fruit depends on the curvature of the surface, the most acute-angled part splitting first. Cracking usually occurs in one of three forms—as deep crescent- or V-shaped cracks near or across the apex of the fruit, as deep straight slits along the body of the fruit (pl. 6, *A–C*), or as circles or semicircles in the stem cavity. Occasionally the tissue lining the cracks dries, partially heals, and escapes infection. Usually, however, secondary organisms such as *Cladosporium* and *Alternaria* enter and cause decay.

Both at the shipping point and on the market, peaches and plums are sometimes found showing cracks that are clearly not due to rough handling or to pressure from a tight pack. These are sometimes called growth cracks. They are known to develop during or after rainy spells following very dry weather, and it is believed that they result from renewed growth of the fruit after the rain. Their chief significance, from the market point of view, lies in the fact that they sometimes become infected with decay fungi (*Rhizopus*, blue mold, gray mold) and from these infection may eventually spread to other fruits in the same package.

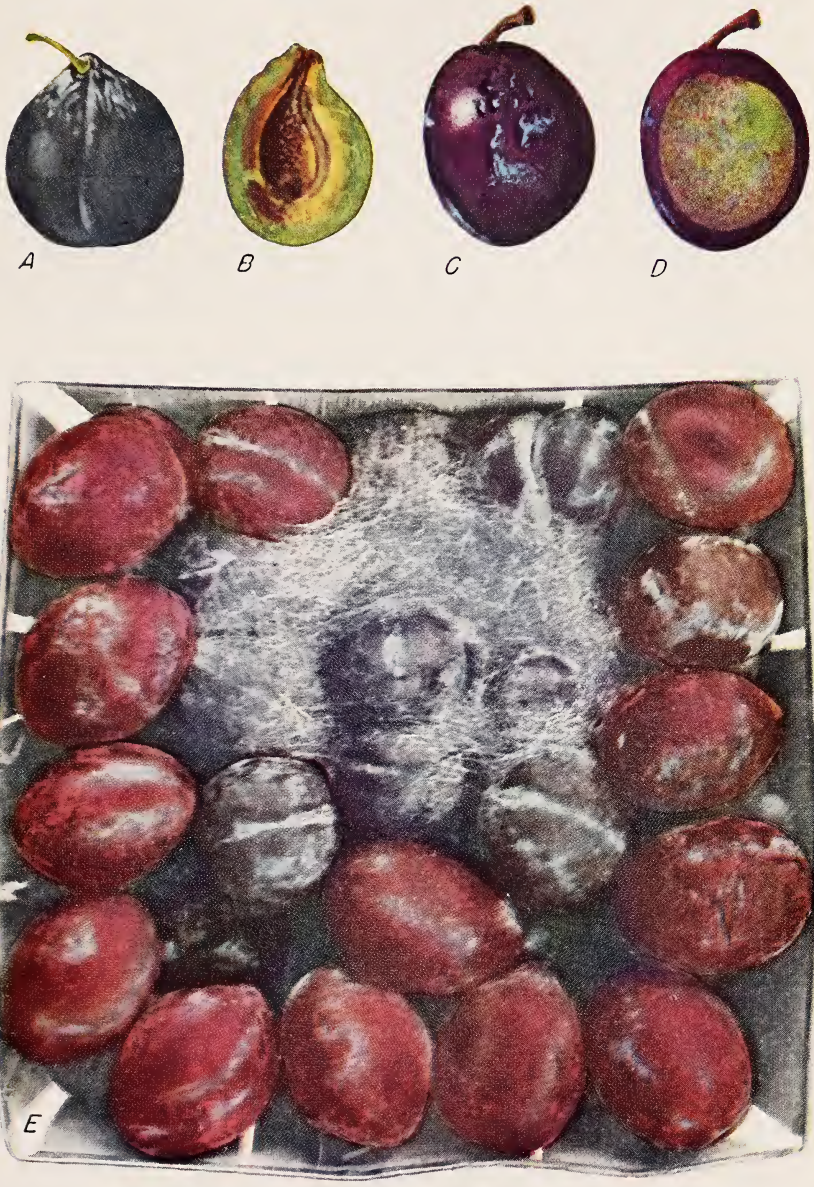
(See *29*, *30*, *57*, *66*.)

DROUGHT INJURY

Drought injury of the Italian Prune has been seen on the market in shipments from Idaho, Oregon, and Washington during seasons when the producing districts of those States had suffered from a shortage of rainfall or of irrigation water. It probably occurs in



A, Spotting of skin of peach after storage at 32° F. for 3 weeks and at 70° for 3 days; *B*, internal break-down of peach after storage at 40° for 2 weeks and at 70° for 3 days; *C*, hail injury of peach; *D*, russeting of plum by thrips; *E*, hail injury of plum.



A–D, Drought injury of prune; *E*, rhizopus rot of plum.

other prune-growing sections of the country. The injury is found in four distinct types, as follows:

(1) Gum spots (gum pocket disease) associated with crescent-shaped scars, ¼ to ⅜ inch long, on the surface of the fruit. The scars resemble curculio injury except that there is no egg-laying puncture beside them. In seasons of severe drought this type of injury is more common in the orchard than any of the others. It is not often seen on the market.

Gum pockets are rather common in some seasons in President plums grown in California, but so far there is no clear-cut evidence as to their cause. Plums of that variety containing gum pockets are sometimes seen on the market.

(2) Shriveling of the prune from the stem end for a fourth to a third of its length, accompanied by browning and blackening of the underlying flesh. The shriveling is probably due to withdrawal of water from the fruit by the leaves in times of water shortage, as is known to happen occasionally in apples, Valencia oranges, and other fruits. There is no evidence that it can increase in transit or storage. This is the commonest type on the market (pl. 9, *A*).

(3) Shriveling of the cheek of the prune, with brown lines of injured tissue extending through the flesh. This type is less common and less serious than the stem-end shriveling (pl. 9, *C*).

(4) Browning of the cells lining the pit cavity. This type of injury has no exterior manifestation, but if severe it injures the eating quality of the fresh fruit, because the affected flesh has a bitter, disagreeable taste. Browning also makes buyers doubtful about the carrying quality of any lot so affected. There is no experimental proof, however, that such lots are any more likely to deteriorate in transit than those that are free of browning (pl. 9, *B*, *D*).

The only suggestions that can be made regarding control are that (1) in irrigated sections no lack of proper irrigation should be allowed to occur if water is available; (2) in any section, no soil conditions that have the effect of drought should be tolerated if they can be prevented by proper soil management; (3) weaker growing stocks such as Agen should not be top-worked with vigorous growers like the Italian Prune, since this practice is known to result in a high percentage of drought injury.

(See *34*.)

FRUIT FLY INJURY

(*Rhagoletis cingulata* (Loew) and *R. fausta* (O. S.))

Cherries infested by fruit fly maggots are misshapen and undersized; they turn red ahead of the main crop, and frequently one side of the fruit is shrunken, partly decayed, and attached to the pit (pl. 10, *A*). The fruit fly larvae, which are often still in the fruit when it is marketed, are yellowish-white, legless maggots, about ¼ inch long when fully developed. These maggots are pointed at the front end, and there is no well-defined head. They may be readily distinguished from larvae of the curculio, which have brownish heads, and from larvae of the oriental fruit moth and the peach twig borer, which are pink or brown and have legs.

Two common species of fruit flies infest cherries—the cherry fruit fly (*Rhagoletis cingulata*) and the black cherry fruit fly (*R. fausta*).

Details concerning their distinguishing characteristics and their life histories are given in the references cited at the end of this section. For the purposes of this discussion, the differences between the species are unimportant.

The cherry fruit flies are found in most cherry-growing districts in the northern part of the United States. In addition to cherries they sometimes infest plums, prunes, and also pears.

These insects may be controlled by spraying the trees with lead arsenate late in June or early in July, but this leaves a residue which must be removed before the cherries are marketed or consumed. More detailed information on control may be obtained from State agricultural colleges or extension services or the United States Department of Agriculture.

Many fruits containing the larvae of either the plum curculio or the cherry fruit flies can be removed by placing infested lots in water and skimming off the fruits that float, which are usually the ones containing worms. The skimming should be done immediately after the fruit is immersed; otherwise some infested fruits are likely to become waterlogged and sink to the bottom with the sound ones.

(See *42*, *45*, *48*.)

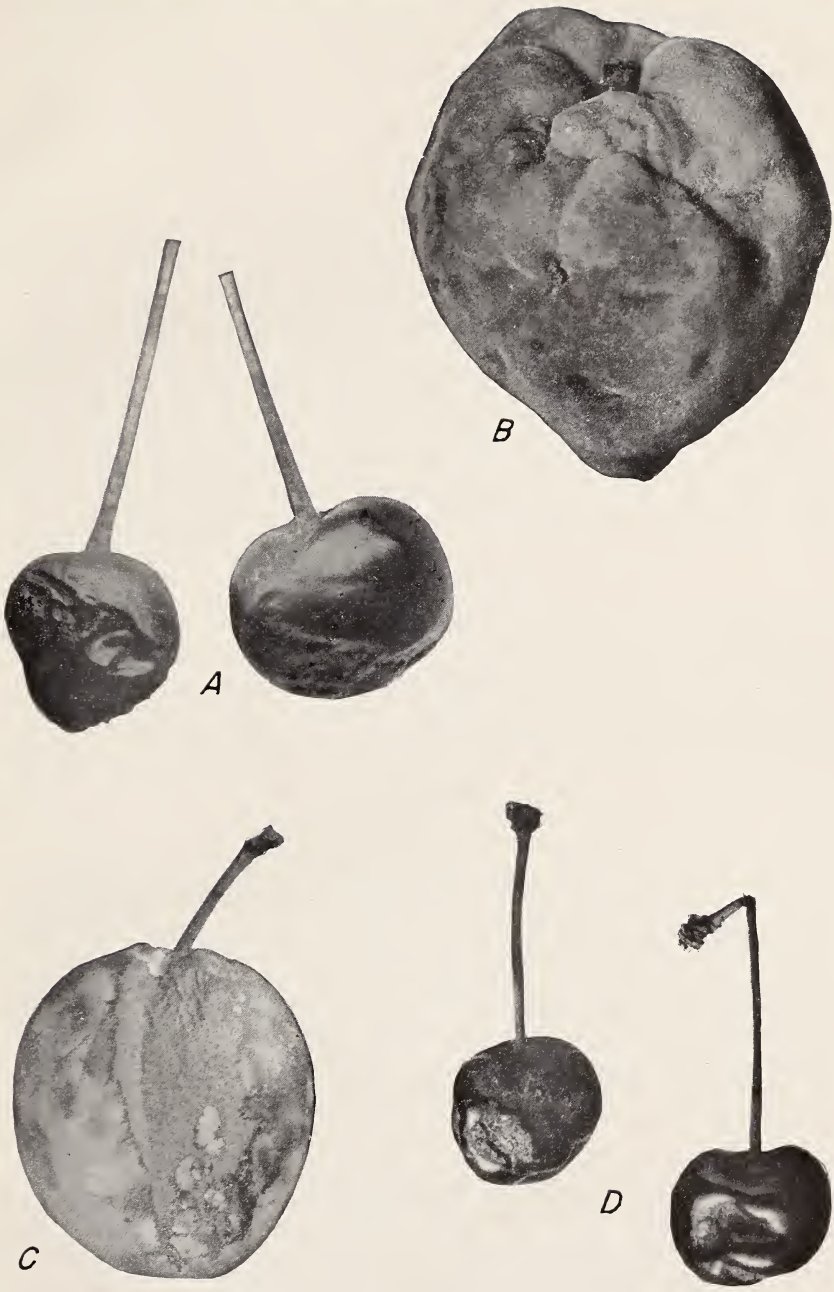
GRAY MOLD ROT

(*Botrytis* sp., probably *B. cinerea* Fr.)

Gray mold rot is one of the common rots of cherries on the market and occurs on fruit from all large producing sections. It is found occasionally on peaches and other stone fruits. In early stages it is characterized by a light-brown spot on the skin covered with extensive, delicate aerial hyphae of the causal fungus and underlain by rather firm, watery, brown affected tissue. As the lesion enlarges, the fungus growth becomes more prominent (pl. 4, *B*). If the fruit is held under fairly dry conditions, abundant spores form on barely visible grayish-brown heads on short hyphae of the same color; under moist conditions, such as are often found in a box of cherries, abundant white mycelium sometimes covers the entire fruit. The skin near the margin of the lesion slips easily under pressure from the finger, as in rhizopus rot (p. 19), but the decayed tissue does not have the odor characteristic of rhizopus rot. In fact, gray mold rot has no definite odor.

Gray mold rot is induced by *Botrytis* sp., probably *B. cinerea*, which produces decay in a wide variety of fresh fruits and vegetables from many sections. This fungus usually enters through breaks in the skin of the fruit; but occasionally it spreads from fruit to fruit through apparently sound epidermis, as evidenced by the fact that a nest of several decayed cherries is sometimes found centering around a cherry in a more advanced stage of decay. The rot develops most rapidly at temperatures between 65° and 75° F., but the usual temperatures in iced refrigerator cars are not low enough to prevent affected areas from enlarging, since some development occurs at temperatures as low as 32°.

Careful handling during picking and packing operations and prompt disposal of culls and rotted fruits are the most valuable control measures known. Cherries given the ordinary commercial handling may show almost four times as much gray mold rot after a 15-day transit period as cherries handled very carefully. Precooling the



A, Cherries shrunken as a result of infestation by cherry fruit flies; *B*, ripe peach injured when small by sucking bugs. *C*, *D*, Syneta leaf beetle injury: *C*, On plum; *D*, on cherry.

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fruit quickly after picking is essential for control, since the decay develops rapidly at temperatures found in the upper part of non-precooled cherry shipments in end-bunker refrigerator cars not equipped with fans (p. 9). (See Brown Rot, p. 6, and Rhizopus Rot, p. 19.)

(See *9*, *39*, *40*, *69*.)

HAIL INJURY

Hail injury consists of irregular, more or less sunken spots which often have dried-up fragments of skin and flesh around the edges or on the surface (pl. 8, *C*, *E*). These spots differ from curculio injury in being larger and in showing little or no gummy exudate and no trace of larval burrows underneath. Because of the way in which they are produced, they generally occur on only one side of the fruit, whereas those due to curculio may occur on all sides. Injury by fruit beetles is sometimes mistaken for injury by hail, but can be distinguished from it by the smooth flat layer of wound cork that lines the beetle cavities. Early hail injury is distinguishable from damage by birds or grasshoppers because the latter occurs late in the season and hence is not likely to heal before the fruit arrives on the market. Fruits struck by hail late in the season are usually so severely damaged that they are not marketable.

INTERNAL BROWNING

Internal browning not caused by cold storage is occasionally found in peaches on the market. The browning may be localized or general. Sometimes it develops first in the flesh next to the stone. It seems to be characteristic of certain varieties, notably the Carman, but there is some evidence that it is connected with soil and weather conditions, particularly drought.

LEAF CURL

(*Taphrina deformans* (Berk.) Tul.)

Leaf curl as a disease of peach and nectarine fruits occurs chiefly in humid sections of California and the Pacific Northwest and in the districts around the Great Lakes. It is not often seen on the market.

The commonest and most destructive form of leaf curl consists in a puckering and curling of the leaves, which begin to develop soon after they unfold in the spring. As the season progresses, the curling becomes more pronounced and the affected tissues become thickened, turn yellow or red, and finally show a characteristic silvery bloom (spores) on the upper surface. Diseased leaves eventually die and drop from the tree. If the attack has been severe the entire tree may be defoliated.

Flowers and young fruits are sometimes affected. The diseased young fruits usually fall early in the season and hence are not often seen. Maturing fruits are often attacked, and as a result large wart-like protuberances appear on the surface or lesions may occur as depressed lacy markings on the undistorted surface of the fruit. In either case the diseased tissues are usually blotched or streaked with red, and those most severely affected may develop deep cracks (pl. 2, *C*, *D*).

Leaf curl is caused by the fungus *Taphrina deformans*. This fungus grows among the cells of the leaves and epidermis of the fruit, stimulating them to abnormal growth that produces the curled, distorted condition just described. The disease is carried over winter by spores that lodge among the bud scales and germinate in moist weather in the spring, infecting the young leaves as they are produced.

Leaf curl is commonest and most severe near large bodies of water or along river valleys where cold, wet weather occurs in the spring, affording conditions favorable to the growth of the fungus.

Leaf curl can be controlled by one thorough spraying with a fungicide—bordeaux mixture, copper sulfate, or lime-sulfur—before the buds begin to swell in the spring.

(See *30*, *31*.)

ORIENTAL FRUIT MOTH INJURY

(*Grapholitha molesta* (Busck))

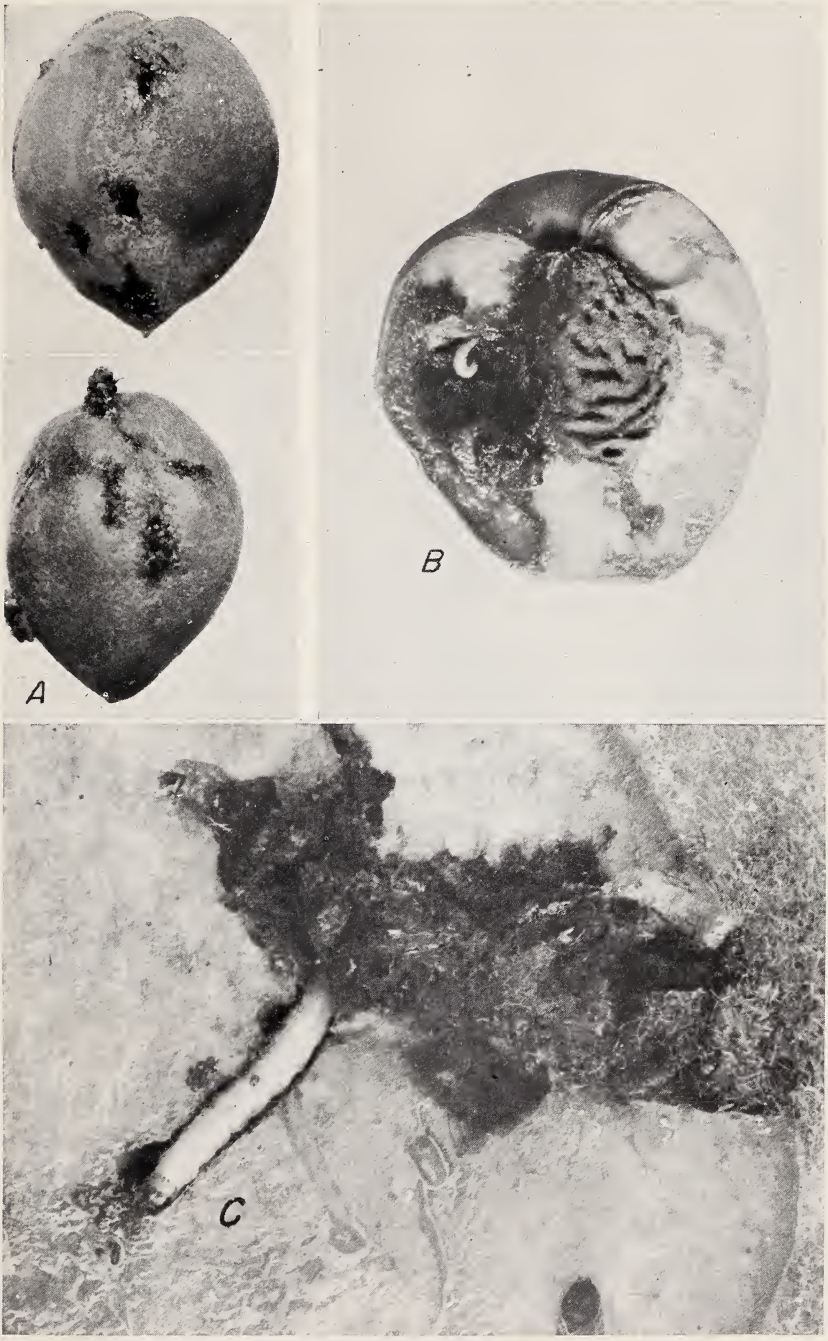
Peaches are very subject to attack by larvae of the oriental fruit moth, which attacks nearly all kinds of deciduous fruits. The larvae tunnel through the flesh, leaving broken-down and decaying areas behind them (pl. 11, *C*). The entrance hole is often very inconspicuous and easily overlooked, especially when the worm entered through the stem or next to it. In such instances a peach may appear perfect externally, even though rather completely broken down internally. In other cases, when entrance occurs through the side, the entrance point may be marked by the presence of frass and gum. The debris left behind by the fruit moth larvae as they burrow through the peach is usually somewhat drier and of a more definite granular form than that left behind by the curculio larvae (p. 17). As the tissues decay and gum is produced, however, the injury by the two species is difficult to distinguish.

The fruit moth larvae are about ½ inch long and are pink when full-grown, whereas those of the plum curculio, often found in the same peaches, are white or faintly yellow. Larvae of the fruit moth have legs; those of the plum curculio (p. 17) are legless.

The fruit moth occurs in nearly all States, but has not yet done much serious damage west of the Mississippi Valley. The degree of infestation varies with the season of ripening. Early in the season the larvae prefer to feed on twigs, but as these harden and the fruits mature, the later generations feed more extensively in the fruit. Normally the varieties earlier than Elberta largely escape serious infestation. The Elberta may be heavily infested, especially if the twigs have hardened and fruit moth larvae happen to be hatching just at ripening time. Varieties of peaches later than Elberta are often very severely attacked.

The fruit moth has been found extremely difficult to control. The Bureau of Entomology and Plant Quarantine has therefore given special attention to the introduction and establishment of numerous species of parasites of the fruit moth. In many localities the parasites have reduced the general level of infestation. The control they give, however, is a little irregular and in some seasons and localities insufficient to prevent serious losses.

Until recently the insecticides tested have given little or no control of the oriental fruit moth. However, DDT has been found to



A, Scarring of peaches caused by egg-laying and feeding activities of curculio; *B*, cut peach showing injury by plum curculio, larva in typical curled position; *C*, cut peach showing injury by oriental fruit moth, × about 4.

have considerable value for this purpose. Schedules for use of DDT that will be the most effective and also safe from a residue standpoint have not yet been worked out. Further work is also needed to determine the effect of these treatments on control by parasites.

(See *42*, *48*, *62*, *65*.)

PEACH TWIG BORER INJURY

(*Anarsia lineatella* Zell.)

Peaches and other stone fruits are sometimes found to contain larvae of the peach twig borer, which produces an injury that cannot be distinguished readily from that caused by the oriental fruit moth (p. 16). As with the latter species, the entrance hole may be very inconspicuous and the injury is usually the most serious in late varieties of peaches. The early broods of larvae feed on the young growth, and as the shoots harden the later ones feed on the fruit.

Twig borer larvae vary in color from a deep pink to a dark brown and are readily distinguished from larvae of the oriental fruit moth and of the plum curculio.

In the Mountain and Pacific Coast States this is the worm most commonly found in peaches; east of the Rockies injury by the curculio or the oriental fruit moth is usually the predominant type.

The peach twig borer may ordinarily be controlled by spraying with dormant-strength lime-sulfur as the buds are pushing out in the spring and beginning to show pink. The addition of lead arsenate to the lime-sulfur increases the effectiveness of the treatment. On apricot trees, which are especially susceptible to injury by lime-sulfur, nicotine sulfate with soap, or lead arsenate with bordeaux mixture, may be substituted for it. In case of severe infestation, the fruit may be protected from the summer broods of worms by spraying with lead arsenate. Because of danger of excessive spray residues, however, this treatment should not be applied too close to harvesttime. As noted elsewhere in this publication, excessive residues of arsenate of lead and other poisonous substances must be removed before the fruit is marketed or consumed.

(See *42*, *45*, *48*.)

PLUM CURCULIO INJURY

(*Conotrachelus nenuphar* (Hbst.))

In the eastern half of the United States the plum curculio is very largely responsible for the presence of wormy peaches on the market, as well as of peaches that are scarred or distorted even though they contain no worms. The plum curculio is a very general feeder on all kinds of fruit, and its work is especially serious on peaches, plums, and cherries.

Early in the spring the beetles emerge from hibernation quarters and make their way to fruit trees, beginning about the time these are in bloom. They puncture the skin of the newly formed fruits for the purpose of feeding and also for laying their eggs. Frequently each egg puncture is partially surrounded by a crescent-shaped slit, which persists on smooth-skin fruits such as plums but generally loses its

shape on the growing peach. The egg-laying and feeding activities of adult curculios result in more or less scarring and, in extreme cases, distortion of the fruit (pl. 11, *A*). The larvae tunnel through the flesh of the fruit and cause a more or less complete disorganization around the pit (pl. 11, *B*).

The curculio larva is a white or yellowish-white grublike worm about $\frac{3}{8}$ inch in length when full-grown. It may be distinguished from other worms found in stone fruits by the fact that it is legless and lies in a curled position. In the adult form the curculio is a brown snout beetle about $\frac{3}{16}$ inch in length.

Punctures caused by the curculio adults in feeding or in laying their eggs frequently serve as entrance points for the brown rot fungus (p. 6), spores of which may be carried on the insect's body or by the wind. Control of brown rot (p. 8) is therefore closely related to control of this insect.

The program for controlling the curculio involves a number of practices: Timely spraying with lead arsenate; in regions where a second brood occurs, the avoidance of excessively heavy applications of material in the final spray; completion of this application not less than 4 weeks before the probable date of harvest; jarring the trees in the spring to capture the beetles when they come out of hibernation; especially in southern areas where a second brood occurs in the same season, the removal and destruction of early-dropped fruits; and thorough cultivation early in the summer while the insect is in the ground in the delicate pupal stage. More detailed information on this subject may be obtained from the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture or from the State agricultural colleges or extension services. As noted elsewhere in this publication, excessive residues of arsenate of lead and other poisonous substances must be removed before the fruit is marketed or consumed.

(See *42*, *48*, *62*, *64*.)

POWDERY MILDEW

(*Sphaerotheca pannosa* (Wallr.) Lév.)

Peach powdery mildew occurs in most of the important peach sections of the United States but is not often destructive in any of them. Varieties do not differ markedly in susceptibility, though in the East the Early Crawford, Late Crawford, and Denton usually suffer more than other varieties. In 1935 the disease was reported as occurring on nectarines in Oregon (*38*).

The fungus attacks leaves, twigs, and fruits, producing on all of these the characteristic irregular white patches of mold (pl. 1, *C*, *D*) composed of mycelium and spores. Underneath these patches on the fruit the skin takes on a brown or dead color; the underlying flesh is rather hard and has a dark, water-soaked appearance which usually extends inward at least half the distance from the skin to the stone.

For control of the disease it is necessary to spray with lime-sulfur or make applications of sulfur dust. For further details the United States Department of Agriculture or the State agricultural colleges should be consulted.

(See *68*.)

RHIZOPUS ROT

(*Rhizopus nigricans* Fr., and possibly other *Rhizopus* spp.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

In peaches attacked by rhizopus rot, affected tissues are light brown, and by the time the peach is badly decayed the flesh is soft though not mushy. At this stage the characteristic coarse white fungus growth and white, gray, or black spherical sporangia, or spore-bearing bodies, appear. They are easily distinguished from the yellowish-gray, spore-bearing tufts of the brown rot fungus (pl. 1, *A*, *B;* pl. 5, *A*, *B;* pl. 12).

In apricots rhizopus rot has much the same symptoms as in peaches. In plums, prunes, and cherries it produces a soft, leaky condition that may or may not be accompanied by slight browning (pl. 9, *E*). In all these fruits a strongly acid odor is usually noticeable when the rot becomes well advanced. In shipments of peaches grown in the East, rhizopus rot is usually about as common and destructive as brown rot; in shipments of those grown in Colorado and other Western States it is frequently the only rot seen.

In cherries the affected areas are at first water-soaked, slightly darker than healthy tissue, and very tender. In late stages the entire fruit is broken down into a red liquid mass and is covered with abundant coarse mycelium (pl. 5, *B*), which early turns to dull black. If slight pressure with the palm of the hand is exerted on the top of a cherry pack containing some of this decay, the face will sink and red juice will drip from the lug. Most of the unsightly red staining of cherry lugs is due to the release of juice because of this decay.

CAUSAL FACTORS

The danger of attack by *Rhizopus* in transit is greatly increased by the presence of skin breaks and moisture. Whether the fruit is attacked depends almost entirely on the temperature at which it is held. For this rot the critical temperature, or danger point, is 50° F. Two or three degrees below this the fruit is fairly safe, provided it has been cooled to 50° or below soon after being picked and the temperature during transit or storage period never exceeds 50°. During the usual number of days in transit for most peach shipments, *Rhizopus* can produce little or no damage at 50° and none at 45°. Whether it can make any start whatever at 45° seems to be determined mainly by the maturity of the fruit. At that temperature it can produce visible rot spots in 6 days on ripe peaches and in 12 days on green ones. Delay in cooling, due either to the loading of warm fruit or to failure to ice cars promptly, is always hazardous. By giving the fungus a longer time in which to work, the delay aggravates unfavorable conditions that may already exist or may cause others to develop that would not have developed if the car had moved on time.

CONTROL MEASURES

In end-bunker refrigerator cars without fans, rhizopus rot, like numerous other rots, is practically always worse at the top of the

load than at the bottom. The commodity temperature at the top of such cars is often 5° to 10° F., and occasionally 20°, higher than at the bottom. The higher temperature allows the rot to develop more rapidly; the temperature in the lower part of the load, even if only a few degrees lower, may control rhizopus rot almost completely.

In cars equipped with fans under the floor racks (driven by the car wheels by means of a belt and friction drive), temperatures are better equalized than in cars without fans. The fans reverse the normal air circulation so that air is driven out from the top bunker opening and over the top of the load; as a result, all parts of the load are cooled at about the same rate. In such cars rhizopus rot is less likely to occur and if it does occur it will usually be found to about the same extent throughout the load. Aside from fans, factors that tend to bring about temperature conditions unfavorable for rhizopus rot are (1) adequate insulation of the car, (2) good mechanical condition of the car, (3) adequate transit icing, and (4) proper stowing of the load to allow air circulation.

Precooling does much to obviate the danger of attack by *Rhizopus* and other fungi, as is shown by tests made in the Northwest with prunes and cherries. Cherries precooled and then held in an iced car showed after 5 days of such storage 2.2 percent of decay; after 10 days, 6.6 percent; and after 15 days, 9.8 percent. Similar lots similarly stored but not precooled showed at the end of 5, 10, and 15 days, respectively, 3.2, 9.2, and 13.5 percent decay. Results equally striking or even more so were obtained with prunes and with both prunes and cherries in tests that compared the effect of delayed and immediate shipment and delayed and immediate precooling.

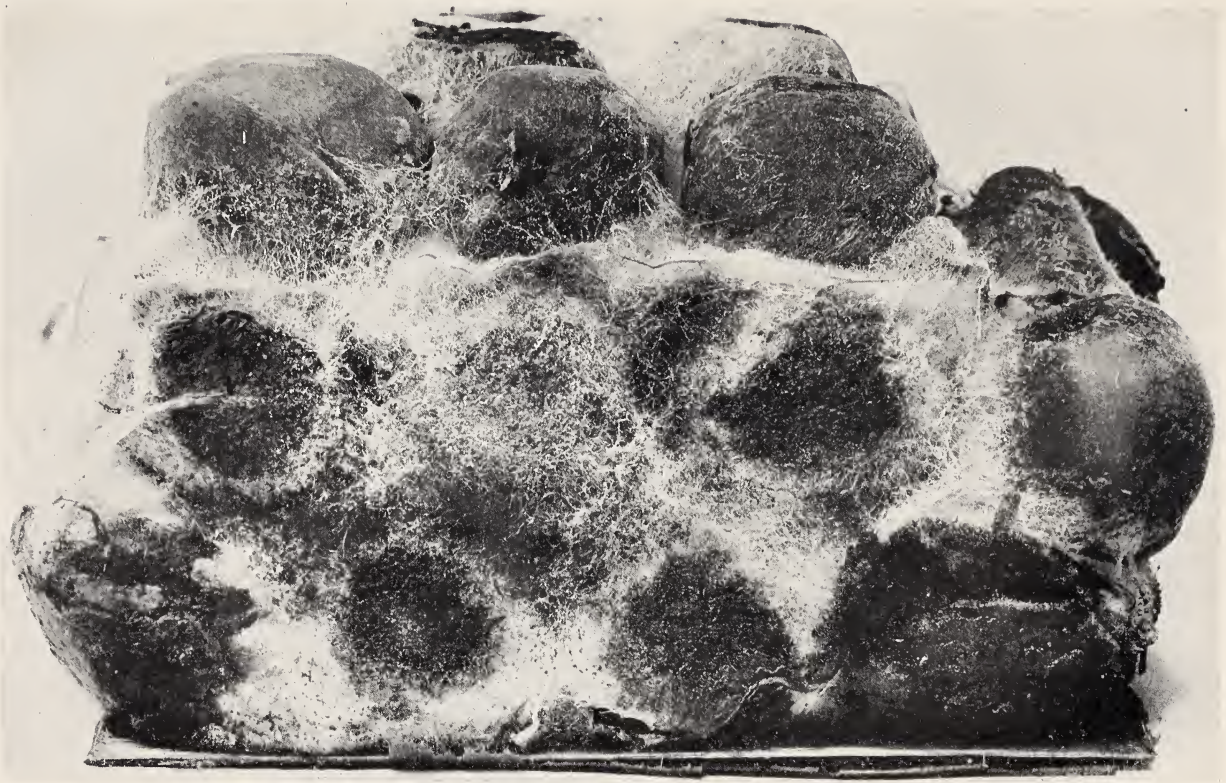
Addition of salt to the ice in the bunkers hastens cooling, although for precooled fruit the quantity added at any one time probably should not exceed 3 percent by weight of the ice supplied at that time, in order to avoid danger of freezing the fruit. If the fruit has not been precooled, 5 percent of salt may be used.

(See *2*, *11*, *12*, *13*, *28*, *67*, *69*.)

RUSSETING

Russeting occurs on practically all varieties of plums and prunes in all producing sections, but it is most common on Tragedy plums and on the Italian Prune variety grown in California and the Pacific Northwest. Irregular, rough russeted spots appear anywhere on the surface of the fruit. These may be caused by the syneta leaf beetle (pl. 10, *C*), by thrips (pl. 8, *D*), by mechanical injury produced by the rubbing of twigs and branches against young developing fruits in windy weather, by frost, and possibly also by other weather conditions. Injury caused by the syneta leaf beetle is usually deeper and rougher than that caused by thrips, because the beetle chews off portions of the skin, whereas the thrips merely rasp the epidermis away and lap up the juice that exudes. On cherries the leaf beetle injury may result in severe distortion of the fruit (pl. 10, *D*). Injury caused by thrips is similar in appearance to that caused by frost, but the surface of the affected area has a finer texture.

(See *25*, *43*.)



Rhizopus rot of peach.

RUST

(*Transzschelia pruni-spinosae discolor* Dunegan and *T. pruni-spinosae typica* Dunegan)

The rust disease caused by *Tranzschelia pruni-spinosae discolor* occurs on cultivated stone fruits throughout the southern part of the United States and in the Pacific Coast States. It causes widespread premature defoliation in some years but little direct economic loss except in the far West, where the fungus occasionally (as in 1925, 1926, and 1927) develops on the fruit. The disease as observed in California occurs almost exclusively on clingstone peaches. The tough, leathery tissues underneath the rust spots interfere with peeling, thus making the fruit undesirable for canning.

Spread of rust in the orchard is favored by rainfall and high humidity. Laboratory studies and field tests indicate that spraying or dusting with some form of sulfur is of value as a means of controlling the disease.

A similar disease caused by *Tranzschelia pruni-spinosae typica* occurs on certain species of cultivated plums and is widely distributed in the United States on wild cherries and plums.

(See *26*, *36*.)

SCAB

(*Cladosporium carpophilum* Thuem.[8])

OCCURRENCE, SYMPTOMS, AND EFFECTS

The fungus disease known as scab originates in the orchard. The causal fungus makes a general attack on leaves, twigs, and fruit, but is of most importance on the fruit. Scab occurs in practically all peach-growing sections of the United States except Washington and Oregon, but is more serious east of the Rocky Mountains than west of them. Plums, nectarines, cherries, and apricots are sometimes affected, but much less seriously than peaches.

Of the diseases of the fruit of peach, scab is second only to brown rot in economic importance. In some years and in some sections the loss from scab has been estimated at 10 percent or more.

On the leaves scab is characterized by brown spots in which the tissue dries up and finally drops out, leaving circular holes. On the young twigs it appears as roughly circular yellowish-brown blotches with dark-gray to bluish borders. The fungus here usually affects only the outer layer, but may girdle and kill the twig.

On the fruit, in cases of mild infection, scab occurs as small circular spots, olive green to black, and usually distinct from one another, which affect only the skin and a shallow layer of flesh underneath (pl. 2, *B*). These spots may occur anywhere on a fruit, but are usually confined to the side that is uppermost as the fruit hangs on the tree. When infection is severe the spots coalesce to form large dark, sooty areas, and the fruit becomes dwarfed or misshapen because of the formation of a protective layer of cork under each diseased area. In such areas cracks frequently develop and a way is thus opened for infection by the brown rot fungus, by *Rhizopus*, or by blue mold.

[8] Not the species that causes cladosporium rot.

CAUSAL FACTORS

Scab is caused by the fungus *Cladosporium carpophilum*. The fungus overwinters chiefly in diseased spots on twigs and under favorable conditions begins to produce spores called conidia soon after the blooming period is past. These conidia are the means by which the fungus spreads to fruits, leaves, and other twigs. They are produced in greatest abundance in wet weather and are believed to be disseminated almost entirely by the splashing of rain water from twig spots onto fruits, leaves, and other twigs. They are probably distributed to some extent also by birds, insects, and wind. The disease is more prevalent in wet than in dry seasons and in sections where the spring and early summer are moist than where they are dry.

CONTROL MEASURES

Scab is strictly an orchard disease and does not develop or spread in transit or storage. It can be controlled by spraying or dusting with some form of sulfur. For detailed information to fit local conditions the United States Department of Agriculture or State agricultural colleges should be consulted.

(See *30*, *31*, *35*, *37*, *51*, *58*, *59*, *64*.)

SPLIT PITS

Peaches and plums of all commercial varieties occasionally have split pits. Affected fruits can sometimes be recognized (1) by their being flattened somewhat at the blossom end and so more nearly spherical than usual or (2) by a visible crack in the flesh and the upper end of the stone, in the stem cavity. Usually the fruit must be cut before a positive diagnosis can be made. Infection with blue mold, gray mold, or *Alternaria* sometimes occurs on the seed or pit, but is not often found to have spread to the surrounding flesh.

In peach-growing sections east of the Rocky Mountains split pits are found generally on trees that have been partly girdled by borers or winter injury or are affected by some other condition that interferes with the downward movement of the elaborated food from the leaves. Investigations in California have indicated that split pits are closely associated with conditions that cause an increased rate of growth of the fruit. Growers in that State have observed that when the fruits grow very large, high percentages of pits are split. Fruits with split pits are fit for human consumption if not otherwise damaged.

(See *8*, *19*, *49*.)

SPRAY INJURY

Spray injury appears on the side or at one end of the fruit as dry, browned, or blackened areas in which frequently the skin and underlying flesh are severely cracked. As it commonly occurs it is nothing more than a severe blemish, although the cracks may open a way for the entrance of decay fungi, particularly the brown rot fungus.

The condition here described is most often caused by the arsenate of lead used for the control of the curculio and is usually confined to orchards where the mixture used was too strong or was applied

in such a way as to drench the fruit. It may be caused also by making the application in bright sunlight during extremely hot weather.

Use of bordeaux mixture, self-boiled lime-sulfur, or other sprays containing lime on sweet cherries is likely to reduce the size of the fruit, and heavy applications shortly before harvest may cause the fruit to become more or less shriveled or wilted.

SUCKING-BUG INJURIES

Peaches and other stone fruits are sometimes pitted, dimpled, scarred, or more or less distorted, as a result of feeding by sucking bugs of various species early in the season, when the fruits were small (pl. 10, *B*). The dimplelike pits caused by these sucking insects are quite characteristic. The more severe injuries, however, take the form of scarred or corky areas which cannot be distinguished from those produced by the plum curculio. The feeding takes place for the most part in the spring or early in the summer, shortly after the adult bugs leave their hibernating quarters.

In the southeastern part of the United States injury of this nature is caused by a member of the squash bug family, *Leptoglossus oppositus* (Say), and by the southern green stink bug (*Nezara viridula* (L.)). In the South, as well as in other areas, the tarnished plant bug (*Lygus oblineatus* (Say)) often causes dimpling, scarring, and distortion of peaches and other fruits. In some localities similar damage is caused by several species of the larger stink bugs. Injury of this general type is often referred to locally as catface.

Control of these sucking bugs is difficult. The injury is always worst in cover-cropped orchards or in orchards that are permitted to become weedy, since most of the species of bugs involved breed on herbaceous plants in and near the orchard. Elimination of cover crops or weeds, when this does not conflict with best orchard practice, is helpful in reducing the amount of injury. In experiments carried on chiefly against the tarnished plant bug, the use of DDT at petal fall reduced the amount of injury by three-fourths or more. Applications made before and during bloom have also given some benefit.

(See *45*, *62*, *63*.)

SULFUR DIOXIDE INJURY

California grapes are customarily fumigated with sulfur dioxide for the prevention of mold and decay. The treatment cannot be used safely, however, in mixed carloads containing stone fruits because of danger of injury to them. The injury (pl. 4, *E*) on peaches is characterized by extensive browning and collapse of the surface tissues of the fruits, accompanied by some sloughing of the skin and underlying flesh. It is not often seen on the market.

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